International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 3.45 (SJIF-2015), e-ISSN: 2455-2585
Volume 3, Issue 10, October-2017

AEXPERIMENTAL STUDY FOR OPTIMUM FUEL INJECTION PRESSURE ON DIESEL ENGINE PERFORMANCE WITH WHEAT GERM OIL

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***Abstract:** Efforts are being made throughout the world to reduce consumption of liquid petroleum fuels wherever it is possible. Bio-diesel is recently gaining much prominence in a substitute for petroleum based diesel mainly due to environmental considerations and depletion of vital resources like petroleum and coal. The vegetable oils are the promising alternative among the different diesel fuel alternatives. For complete combustion of the fuel in the cylinder the fuel injection parameters play a major role. The major parameters are mainly fuel nozzle holes, fuel droplet size and fuel injection pressure. These parameters can influence the engine performance and emission characteristics of an I.C. engine. In this work, experimental study was carried out tests used a blend of wheat germ oil and diesel in a single cylinder, 4-stroke water cooled light duty injection diesel engine at different injection pressures 175, 185 and 195 Bar. The tests were carried out for pure diesel and blend of 20 % wheat germ oil by volume in diesel at constant speed with varied loads. The performance results at 185 to 195 Bar of blend very nearer to pure diesel results. The emissions UHC, CO and CO_2 are very less at 185 Bar compared to pure diesel. The NO_x emissions are lesser for blend at 195 Bar than pure diesel. The overall performance is good at 185 and 195 Bar. But the emissions are decreased when increasing injections pressure.*

***Keywords:** wheat germ oil, Diesel engines performance, fuel injection pressure, UHC- Unburned hydro carbons, CO- Carbon monoxide, NOx emissions.*

1. INTRODUCTION

The definition of engine is to convert heat in to work called heat engine. In this heat is low grade energy and work is high grade energy. Heat engines are either external combustion engines or internal combustion engines. The Internal combustion engines having higher efficiency than the external combustion engines and emits fewer pollutants in this diesel used as a fuel. The main idea of alternative fuels is good reserves in the sector of transportation because they will not only assist to the environmental quality but also has distinct positive socioeconomic results. From last century many number of scientists had suggested that the bio-fuels are good alternatives to fossil fuels. In present research we will introduce Wheat germ oil as an alternative fuel. In present experimental investigation we are purchased Wheat germ oil at Falcon (Exports & Imports of natural essential oils) in Bangalore. In present day's major pollutants from automobiles are unburned hydrocarbons (UHC), oxides of Nitrogen (NO_x), Carbon monoxide (CO), sulfur compounds and lead compounds and particulates.

In present diesel engines, the fuel injectors are designed to maintain higher injection pressure for the purpose of acquiring better performance results. The main intention of this design is decrease the exhaust emissions and increasing the efficiency of the engine. The fuel injection pressure is inversely proportional to the fuel droplet size. The fuel droplets diameter is increases at lower injection pressures then the ignition delay period is increases during the combustion. This situation leads to increase the injection pressure. Engine performance will be decrease since combustion process goes to bad condition. When injection pressure increased the fuel particle size decreased. The mixture of fuel and air formation becomes better from that complete combustion was done in the cylinder during the ignition period. When injection pressure is high the ignition delay period is shorter. The homogeneous mixture is leads to higher combustion efficiency.

2. THE INJECTION PRESSURE VARIATION

To acquire high degree of fuel atomization needs high injection pressure in the fuel injection system. For the purpose of sufficient evaporation of fuel in very short time. From that the fuel particles achieve sufficient spray penetration in order to exploit the fuel air charge in the cylinder. The fuel injection system should have measured the amount fuel desired, depending upon engine load and speed, and inject the fuel at desired rate in correct time. The appropriate shape and size of fuel particle obtained based on the particular combustion chamber. Generally, a supply pump withdraws the fuel from fuel tank and carries it's via a filter to the fuel injector. In present investigation the injection pressure varied from 175 to

195 bar. Normally the injection pressure is 185 bar for high speed diesel engines. In this the injection pressure is varying by tightening or loosening the screw provided top of the injector as shown in fig. 1. For measurement of fuel injection pressure on fuel injector system by using fuel injector pressure tester as shown in fig.2

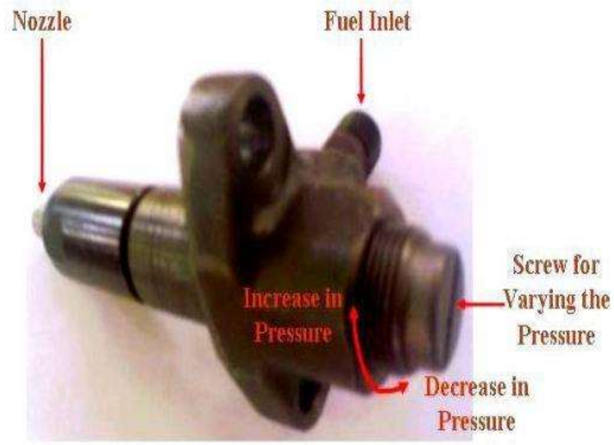

Fig.1 Fuel Injector

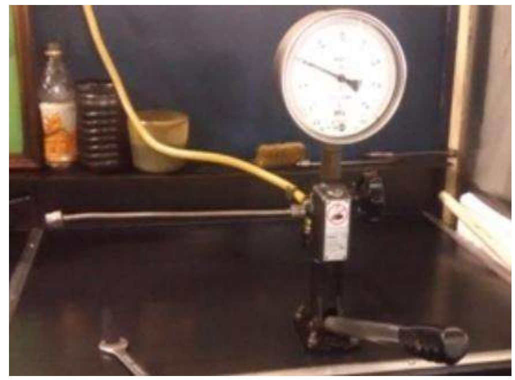

Fig.2 Pressure Tester Gauge

Fig.3 Diesel engine fuel injector

In present research Experimental tests are carry on 4-stroke single cylinder diesel engine used Wheat germ oil as fuel and with proportion of diesel at different injection pressures usually 175,185 and 195 bar. The injection pressure is one of the main characteristics which affect the performance and emission characteristics of a diesel engine. The tests were carried out for pure diesel and blend of 20% Wheat germ oil by volume in diesel by varying loads at different rates

Table 1: Engine specifications

Make	KIRLOSKAR
Type	Single cylinder, four strokes, water cooled
Capacity	5 HP
Bore Diameter	80 mm
Stroke length	110 mm
Speed	1500 rpm

Eddy Current Dynamometer Temperature Points

1. Inlet
2. Water inlet to engine
3. Water inlet to calorimeter
4. Water outlet from engine
5. Water outlet from calorimeter
6. Exhaust gas inlet to calorimeter
7. Exhaust gas outlet from calorimeter

3. Test engine and fuel properties

The experiments were carried out on a naturally aspirated, water cooled, single cylinder, direct-injection diesel engine. The specifications of the engine are shown in table 1.

Table 2: Properties of Diesel and wheat germ oil (Source: Fuels laboratory GKVK-Bangalore)

PROPERTIES	DIESEL	WHEAT GERM OIL	B20
Density (Kg/M^3)	850	957	870
Kinematic Viscosity @ 45 ^0C (c St)	2.82	17.1	4.53
Calorific Values (KJ/Kg)	42570	41700	42340
Fire Point (^0C)	87	205	97
Flash Point (^0C)	81	197	85
Cetane Number	46	54	51
Lower Heating Value	42.3	39.4	42.25

4. Engine procedure

The experimental work had conducted on 4-stroke diesel engine. In diesel engine four strokes are utilized namely suction, compression, power and exhaust strokes for completion of cycle. The 4-stroke diesel engine consists of two valves i.e., inlet valve and exhaust valve. In this the inlet valve is used for sucking the fuel charge or pure air into the chamber at beginning of suction stroke and the exhaust valve is used for removal of exhaust gases from engine cylinder at the end of combustion stroke. The piston is moving from top dead center to bottom dead center at starting the cycle. The piston begins from TDC to BDC at suction stroke the inlet valve opens and the fuel charge is sucked into the combustion chamber then compressed at compression stroke. At end of compression stroke spray of fuel injected into the cylinder the fuel complete combustion obtained in cylinder at power stroke. End of power stroke the exhaust gases are released. The exhaust gases are sent to out through exhaust manifold at exhaust stroke. This cycle follows by 4-stroke diesel engine.

5. Engine equipment

A single cylinder 4-stroke water cooled diesel engine having 5 HP as rated power at 1500 rpm was used for the research work. The engine was coupled to an electrical dynamometer for loading it. The engine equipment is completely digital system. The speed and different temperatures are note down from the digital indicator. The equipment set-up of the engine is shown in figure.

Figure.4

Precautions:

(1) Give the necessary electrical connections to the panel and also check the lubricating oil level in the engine
(2) Check the fuel level in the tank

6. Procedure of experiment

1. Allow the water to flow to the engine and calorimeter and adjust the flow rate to 6 lpm & 3 lpm.
2. Release the load if any on the dynamometer.
3. Open the three-way cock, so that the fuel flows to the engine.

4. Start the engine by cranking.
5. Allow to attain the steady state.
6. Load the engine by switching on the loading switches.
7. Note the following readings for particular condition,
    a. Engine speed
    b. Time taken for 10cc of fuel consumption
    c. Rota meter reading
    d. Manometer readings, in cm of water
    e. Temperatures at different locations
    f. Note pollution values from the pollution setup i.e., multi gas analyzer system.
8. Repeat the experiment for different loads at different fuel injection pressures i.e., 175,185 & 195 Bar and note down the above readings
9. After the completion release the load and then switch of the engine.
10. Allow the water to flow for few minutes and then turn it off.

7. Results and Discussios

Experimental investigation is performed on diesel engine by varying fuel injection pressure visually 175, 185, 195 Bar. The results are discussed below.

A. Effect of Brake Thermal Efficiency (BTE)

The variation in brake thermal efficiency with different loads at varied the injector opening pressures like 175, 185 and 195 bar when diesel and B20 wheat germ oil fuels used as injected fuel, is shown in fig5. A higher brake thermal efficiency is obtained for B20 blend at 195 Bar compared to diesel at 60% load. When increasing the load up to full load the efficiency is decreased due to very improper combustion and very fine droplets of fuel have less momentum. Since viscosity of the bio-diesel is high, it requires large heat source for combustion of fuel at lower injector opening pressure. But at higher injector opening pressure, atomization and penetration of injected fuel is good and hence the injector opening pressure 195 Bar results in higher brake thermal efficiency at 60% of full load. The overall brake thermal efficiency is increased for diesel from lower to higher load at 175 and 195 Bar. This is due to that reduction of heat loss from the engine and the producing power increases with increasing load. The overall thermal efficiency of B20 wheat germ oil is slightly lesser than that of the diesel at all pressures. The main reason behind that the poor mixture formation i.e., due to higher viscosity, higher density and lower volatility of wheat germ oil fuel.

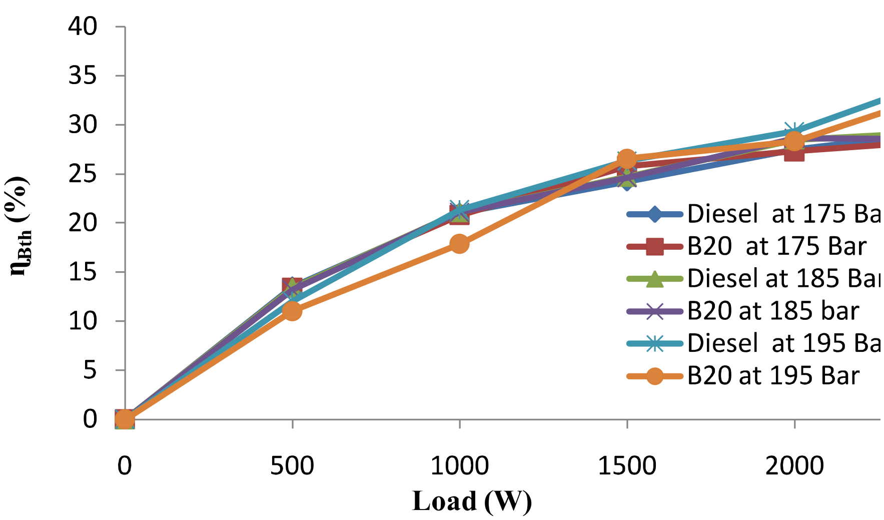

Figure 5: Comparison of Brake thermal efficiency

B. Effect of Brake Specific Fuel Consumption

The specific fuel consumption is changed with load at different pressures for diesel and B20 wheat germ oil was presented in fig 6. The BSFC is decreases with increasing loads for all pressures. This result may due to poor mixture formation wheat germ oil and effect of higher viscosity. The specific fuel consumption of B20 blend is lesser than that of diesel for 3rd and 4th loads at 195 Bar compared to other injection pressure for both sources. This result caused when increasing the injection pressure the fuel droplets size decreases and then the fuel droplets momentum increases. And they have collided on the engine cylinder wall then produce same power, the fuel consumption also increased. From all pressures the diesel has lower BSFC value at 175 Bar at full load condition.

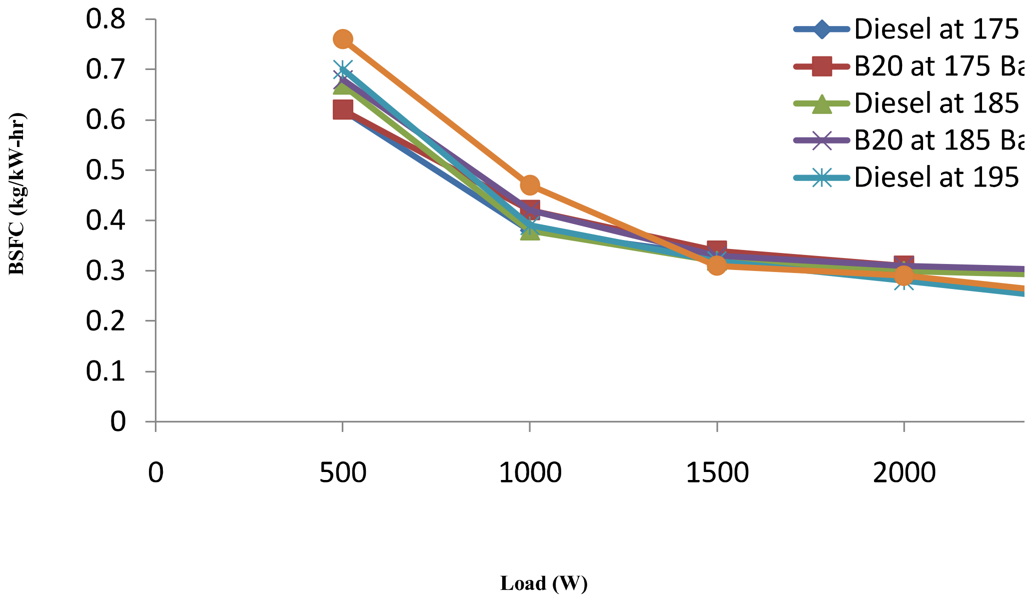

Figure 6: Comparison of specific fuel consumption

C. Unburned Hydrocarbon Emissions

The Unburned hydrocarbons are varied at three different injection pressures for diesel and B20 wheat germ oil shown in fig7. As the opening pressure increases the HC emissions are reducing because, higher injection opening pressures will lead to proper spray while the injection starts. This will enhance the performance with B20 wheat germ oil have higher viscosity. This is probably because of the improvement in the spray, which can lead to a lower physical delay. The improved spray also leads to better combustion and thermal efficiency. The unburned HC Emission is highest in the case of 175 Bar and is least in the case of 195 Bar. This is because at 195Bar proper diffusion and combustion of the biodiesel takes place which results in lower emissions. At 175 Bar and 195 Bar there is very less time for the diffusion of the fuel to takes place which leads to increase in emissions. The concentration of biodiesel increases in the blend the unburned hydro carbons are decreases due to that the oxygen content present in the biodiesel is higher this leads to complete combustion in the cylinder.

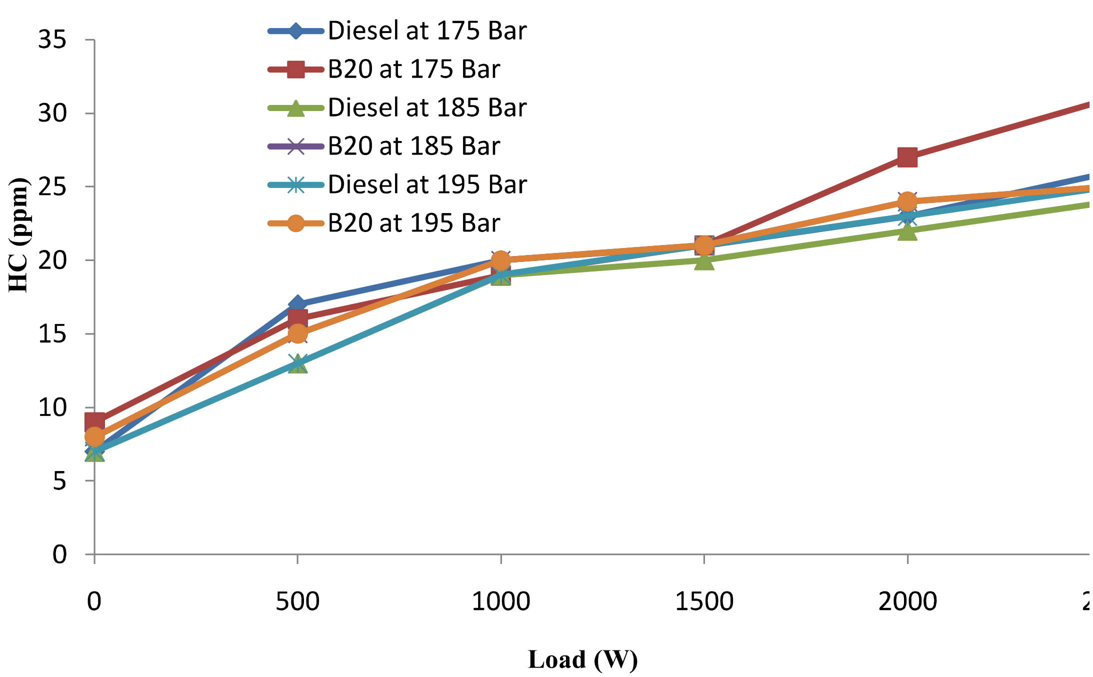

Figure 7: Comparison of HC emissions

D. Carbon Monoxide (CO) emissions

The variation of carbon monoxide emissions with load at different injector pressures, when pure diesel and B20 wheat germ oil are used as a injected fuel, is shown in fig 8. At full load, for the injector opening pressure of B20 wheat germ oil, due to higher injection pressure, atomization and mixing process are improved. Due to high viscosity of wheat germ oil compared to diesel, high injection pressure are required for improving atomization and better mixing process resulting in low CO emissions. The CO emissions are decreased when increasing loads at all pressures. The CO emissions B20 wheat germ oil is lower if compared to pure diesel. The wheat germ oil produces a greater combustion efficiency leading to lower amounts of CO. The CO emissions are very less at 175 Bar for B20 Blend compared to diesel at all pressures and higher for diesel at 175 Bar.

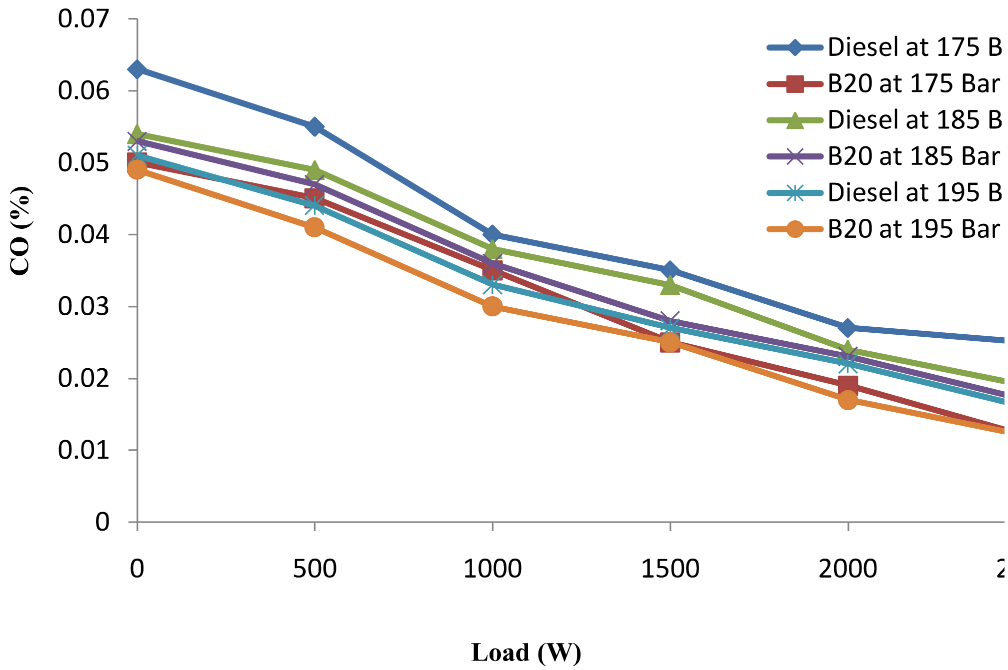

Figure 8. Comparison of CO emissions

E. Oxides of nitrogen (NOx) emissions

Fig9. Shows NO_x variation with increasing loads at all pressures for B20 wheat germ oil pure diesel. From graph the NO_x emissions are increased with increasing loads for all pressures due to the increase in combustion temperature. . The important factor that causes NO_x formation is due to high combustion temperatures and availability of oxygen. The NO_x graph indicates that B20 blend of wheat germ contain lower NO_x emission when compared to pure diesel fuel. This is due to poor atomization of wheat germ oil leads to poor combustion and lead lower NO_x emission. The NO_x emissions are increased with increasing the load for both fuels. But less NO_x emissions are obtained for B20 wheat germ oil than that of diesel at all pressures. The reasons may be due to

(I) Smaller calorific value of blend,

(II) Lower localized gas temperature in the cylinder,

(III) Oxidation rate,

(IV) Poor atomization due to high viscosity.

The diesel fuel contains high volatile nitrogen compounds in their composition which contributes to a higher level of nitrogen concentration in the combustion chamber. Since diesel engine operates primarily in the lean region when diesel fuel is consumed, there is excess air and oxygen for nitrogen compounds to form NOx when the combustion temperature is high.

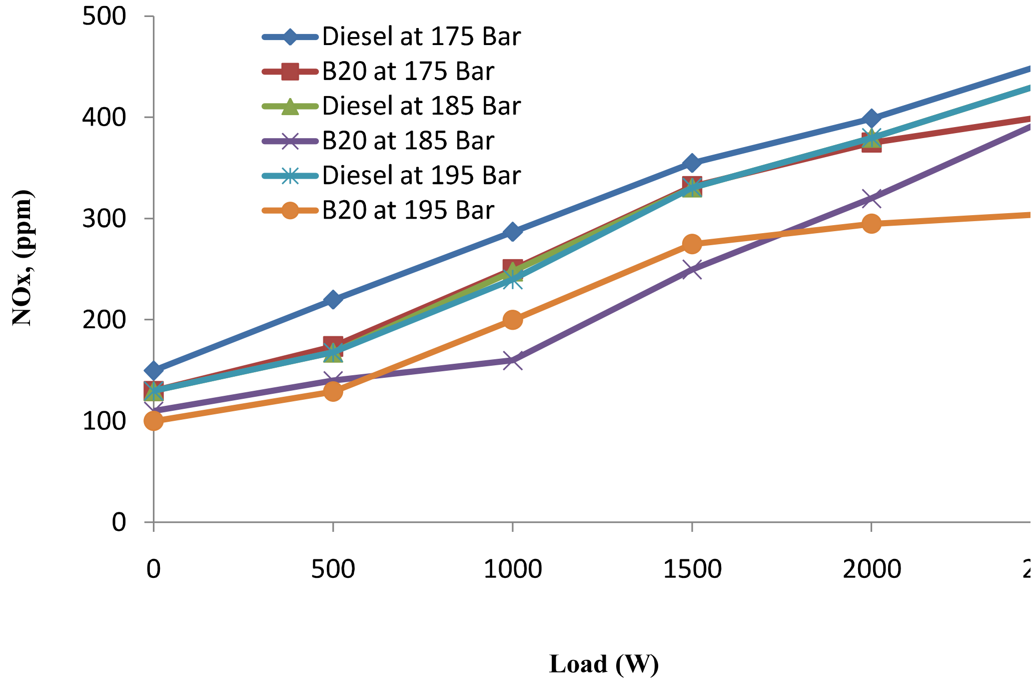

Fig9. Comparison of NOx emissions

F. Carbon dioxide (co_2) emissions

A variation in the values of CO_2 emissions for diesel and B20 blend at all injection pressures are shown in Fig.10. The CO_2 emissions are increased with increasing loads for diesel and blend for all loads. Carbon dioxide is a desirable byproduct compared to CO emission that is produced when the carbon from the fuel is fully oxidized during the combustion process. From the graph lower CO_2 emissions obtained for B20 wheat germ oil than that diesel at all pressures. The lowest emissions obtained for B20 blend at 195 Bar because of lower carbon content of biodiesel and highest emissions obtained for diesel at 175 Bar. This is mainly due to improper combustion of fuel efficiency.

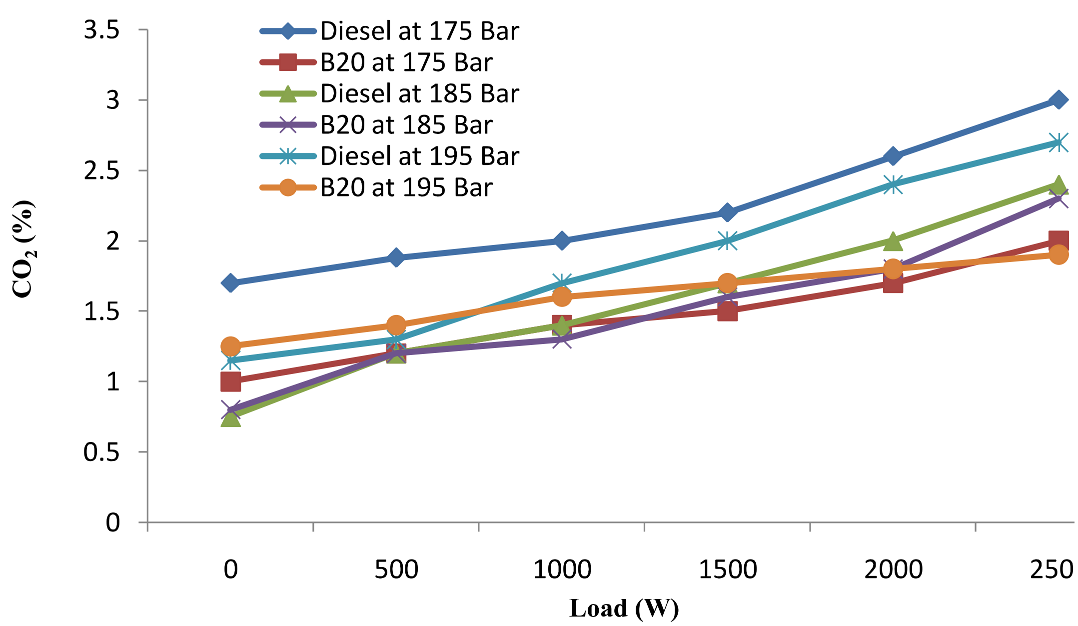

Fig 10. Comparison of CO_2 emissions

8. Conclusions

From the experimental study following conclusions were drawn:

- The Brake specific fuel consumption is high for the blend of wheat germ oil and diesel mode. As the injection pressure increase, the Brake specific fuel consumption is decrease.
- The BSFC of blend was taken i.e. minimum at 175 bar injection pressure.
- The brake thermal efficiency of biodiesel is very close to diesel from 185 to 195 Bar. However, at 60% load BTE is higher for biodiesel at 195 Bar than diesel.
- The mechanical efficiency of B20 is higher at 185 Bar than 175 and 195 bar.
- The CO and CO_2 emissions are low for B20 at 195 Bar than diesel.
- Lower exhaust temperatures were observed at higher injection pressures.
- The NOx emissions are very low for B20 than diesel at 195 Bar when compared to 175, 185 Bar injection pressures.
- The UHC emission of B20 is less at all loads compared to diesel.
- Based on the experimental investigation it can be concluded that B20 of wheat germ oil can be adopted as an alternative fuel for existing conventional engine without any major modification required in the system hardware.

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